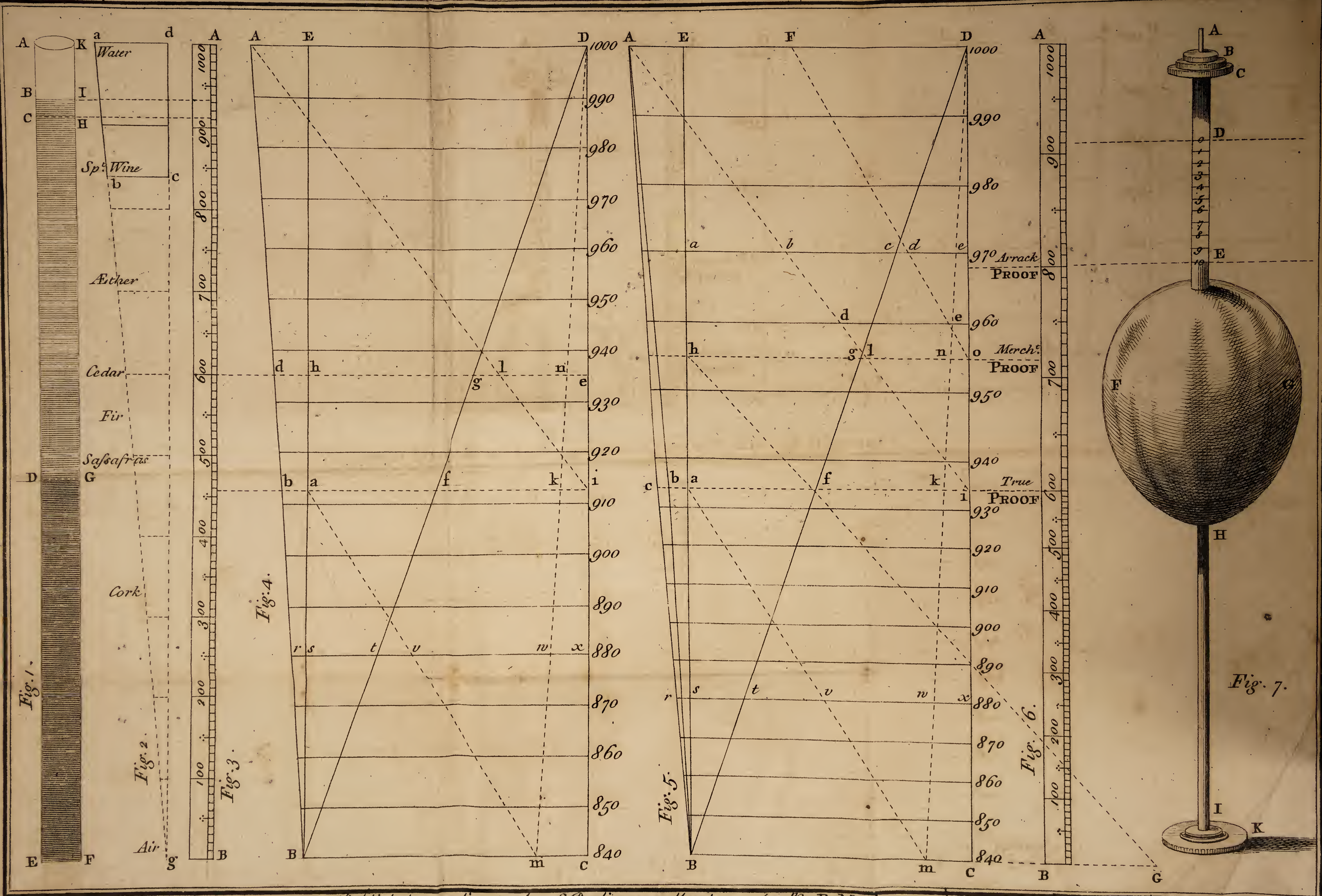
The THEORY *of the* Genuine HYDROMETER *illuſtrated.*



Publiſh'd according to Act of Parliament March 25 1762. By B. Martin.

A
SURE GUIDE
TO
DISTILLERS,
AND ALL
DEALERS
IN
SPIRITUOUS LIQUORS,

For diſcovering.

The True Proportion of *Water* and *Alchohol*
in any propoſed Compound;

AND

How to make it exactly PROOF,

BY

A New-conſtructed HYDROMETER, and SCALE of
Lines, whoſe Uſes are deſcribed and illuſtrated by
Examples.

The Whole deduced from a Mathematical THEORY
founded on *Philoſophical Principles* and *Experiments*.

By *BENJAMIN MARTIN.*

This HYDROMETER is made only by Him, and Sold at his Shop,
the Sign of the *Viſual-Glaſſes* and *Globe*, in *Fleet-ſtreet*, 1759.

Seven

Price One Pound [redacted] Shillings.

TO THE

Hon. COMMISSIONERS

OF

His Majeſty's REVENUES

OF THE

CUSTOMS and EXCISE

RESPECTING

The DUTIES on SPIRITUOUS LIQUORS.

Gentlemen,

I Have preſumed on the Liberty of addreſſing to You an Eſſay on the Nature and Structure of a *genuine* HYDROMETER, as it is an Inſtrument that is beſt fitted to *analyze*, and thereby to diſcover the component Parts of *Spirituous Liquors*; a Subject of great Extent in the Public Revenues of theſe Kingdoms; and which his MAJESTY has committed to your immediate Care, Inſpection, and Regulation.

An Inſtrument, therefore, of this Sort muſt be of high Importance to a Community which not only imports great Quantities of different Sorts of Spirits from Abroad, but employs ſuch an extenſive DISTILLERY at Home entirely on that Subject; beſides the frequent and neceſſary Uſe of an HYDROMETER in aſcertaining the ſpecific Gravity of mineral, medicinal, and other Waters, and Fluids produced by, and uſed in the various commercial, chemical, and oeconomical Arts and Manufactures of this Nation.

But as I have not yet ſeen any Inſtrument that can be properly called an HYDROMETER, *viz. one that depends on a juſt Theory, that will aſcertain the ſpecific Gravity, and will truly aſſign the Proportion of the conſtituent Parts of a Compound Fluid, both in regard to Quantity and Weight*, I have attempted ſuch a Conſtruction, and have now the Honour to offer it to your critical Conſideration and Examination,

In every Department of his Majeſty's REVENUES relative to the Duties on *ſpirituous Liquors*, there are not wanting Gentlemen of *Mathematical* Abilities much beyond what is neceſſary to render them competent Judges of the Nature and Conſtruction of this Inſtrument, as here repreſented in the Diagrams of the Copper-plate; and who cannot but be apprized that a *genuine* HYDROMETER muſt not pretend to a leſs Number of either *phyſical* or *geometrical Principles* than they will here find premiſed to this.

I therefore ſubmit this HYDROMETER to the *Examen* and Cenſure of Gentlemen, who by their Situation and Learning, are ſuperior to every Intereſt and Influence, but thoſe of *Truth* and the *public Welfare*. Their Sentiments of it ought to direct the *Public* in their Opinion of its Uſefulneſs. And then there will be no Room to doubt but this Invention will have all the Regard which is due to its Merit from every Party concerned in ſo intereſting a Subject, as the *making*, *importing*, and *vending* Spirituous Liquors; and that is all that is deſired or expected by the Author, who has ſpared no Pains to make this Inſtrument as compleat, and as eaſy to be underſtood both in THEORY and PRACTICE, as any Thing of ſuch a Nature can be; and who is, with profound Submiſſion,

Gentlemen,

Your moſt humble

And moſt obedient Servant,

Fleet-ſtreet,
London.

B. MARTIN.

PREFACE.

IT muſt be allowed that equal Weights of Water and Spirit, or Alchohol, mixed together, make the only true and juſt Proof, *becauſe in that Caſe only the* Quantity of Matter *in each can be equal. And if the* ſpecific Gravity of Water and Spirit *be taken in ſuch Proportion as I have here ſuppoſed to be the beſt, then this* HYDROMETER *I preſume, is conſtructed geometrically and phyſically exact; and I make no doubt of its being the firſt that ever was ſo. For ſuch an Inſtrument can never be true if it be not conſtructed by the Rules of* Algebra, *and by an* hydroſtatic Theory *nicely corrected by Experiments. They who make Hydrometers without theſe Principles may be juſtly ſaid* (operosè nihil agere,) *to take great Pains to no Purpoſe, unleſs to deceive themſelves and the Public; and tho' this Invention may ſeem no great Matter, I can aſſure the Reader it has coſt me more Time, Trouble, and Expence than any Inſtrument I have ever yet made public. The Uſe of it may be greatly extended; but I have accommodated it at preſent only to the Service of the* Diſtiller *and* Compounder, *to whom I apprehend it muſt be very acceptable, ſince without it, all muſt be Gueſs-work which they do. At firſt I determined not to trouble the Reader with the* MATHEMATICAL THEORY, *but finding the Inſtrument greatly diſparaged, and myſelf abuſed for the Contrivance, I was obliged for my own Juſtification to publiſh it; and I hereby appeal to any* MATHEMATICIAN *for the Truth of it in every Part; the Criticiſms or Cenſures of any other Perſon not meriting the leaſt Regard.*

THE Deſcription and Uſe OF A NEW HYDROMETER.

I. *Of the* SCALE *of* LINES.

1. THE Reſult of a great Number of Experiments (which from Time to Time I have made purely in regard to this Subject) has convinced me that the beſt Proportion of the *Specific Gravities* of *Water* and *Alchohol*, or *Spirit*, is that of 1000 to 840, with reſpect to their Compoſition for PROOF-SPIRIT. And the Difference of theſe Numbers, *viz.* 160, make the Diviſions of the *firſt Line* A B in the SCALE at the End of this Treatiſe.

2. In the ſecond Line C D the Diviſions are ſtill the ſame, only they are number'd in the natural Order from 840 to 1000; that ſo they may ſerve to ſhew or expreſs the common *Specific Gravity of any Compoſition of Water and Spirit.*

3. The Diviſions of the Third Line E F and fourth G H are the ſame, *viz.* 1000, but number'd forward in one, and back-

ward in the other, that ſo the Numbers in one may be the *Complement* of thoſe in the other to 1000.

4. Therefore if the whole Difference of Weight of the *Hydrometer* in Spirits and Water be divided into 1000 equal Parts, and theſe Parts be expreſſed by the Diviſions of the Line E F; then the Number of theſe ſmall Weights put into the Cup to make it ſink in *any compound Spirit*, will ſhew the common *ſpecific Gravity* of it, by the correſponding Number in the Line C D. For Example, if the Weights required to ſink the Hydrometer to (0) be 700, then will the ſpecific Gravity of that Compound be 952 nearly, or the Weight of that compared with the Weight of Water in equal Bulks will be as 952 to 1000.

5. Hence it is evident, the Numbers in the Line E F repreſent the *Bulk of Water* in any ſpirituous Compound, and thoſe of the Line G H, will ſhew the *Bulk of Spirit*; for theſe Numbers will increaſe and decreaſe in the ſame Proportion every where with the *Bulks of Water and Spirit* in the Compound.

6. The fifth Line I K contains 840 Diviſions numbered from the right Hand to the left; and therefore if the Diviſions in the third Line E F repreſent the *Weight of the Water* in any Compound, thoſe in the Lıne I K correſponding to them will repreſent the *Weight of the Spirit*; ſince every where

thoſe Numbers increaſe and decreaſe with the Weights of thoſe Fluids reſpectively.

7. It is to be remembr'd that PROOF-SPIRIT is that which conſiſts of *equal Weight of Water and Alchohol*; and therefore where you ſee the ſame Number in the third and fifth Line coincide, there will the common *ſpecific Gravity* of that Proof-Spirit be expreſſed in the ſecond Line. For Example, the Number 456 in the Line E F coincides with the ſame Number in the Line I K; and correſponding to theſe is the Number 913½ in the Line C D; therefore the ſpecific Gravity of *Alchohol*, *Proof-Spirit* and *Water*, are as 840, 913½, and 1000, as they are uſually eſtimated.

8. Therefore if the Compound be ſuch as requires a leſs Weight than 456 in the Cup to ſink the Hydrometer to (0) then it is *above Proof*; if it require juſt 456, it is *juſt Proof*; but if more than 456 be put into the Cup, then it is *below Proof* according to the Cuſtomary way. And thus you ſee the Scale is marked on the Top.

9. The ſixth Line L M ſhews the Quantity of Water to be added to the Compound, if *above Proof*, on the left Hand, or the Quantity of Spirit to be added if the Compound be *below Proof* on the right Hand of the Proof-Point, ſo that the Compound may be *juſt Proof*. And theſe Numbers are ſuch Parts, of which the whole Compound conſiſts of 1000.

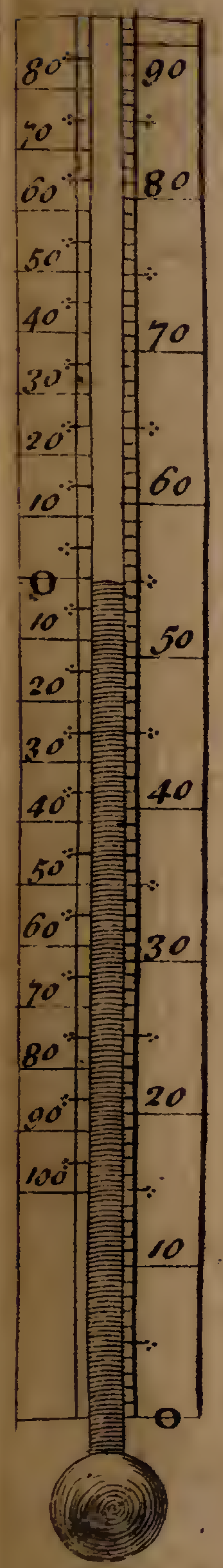
10. But before we can arrive at the exact Truth, the Numbers of the ſecond Line C D muſt be new modelled, and expreſſed as in the ſeventh Line N O; *this Correction* not having been attended to, has rendered all Hydrometers that have been hitherto made, very imperfect and erroneous. And theſe Diviſions or Numbers in the Line N O have been deduced by Calculations founded on ſuch Experiments as were neceſſary to aſcertain the *True Denſity or ſpecific Gravity* of a given Compound which is very different from what is uſually ſuppoſed; or inferred from the common Algebraic Proceſs. This Line N O of *correct ſpecific Gravities* is therefore to be uſed conjointly with the Line C D, as we ſhall ſhew in what follows.

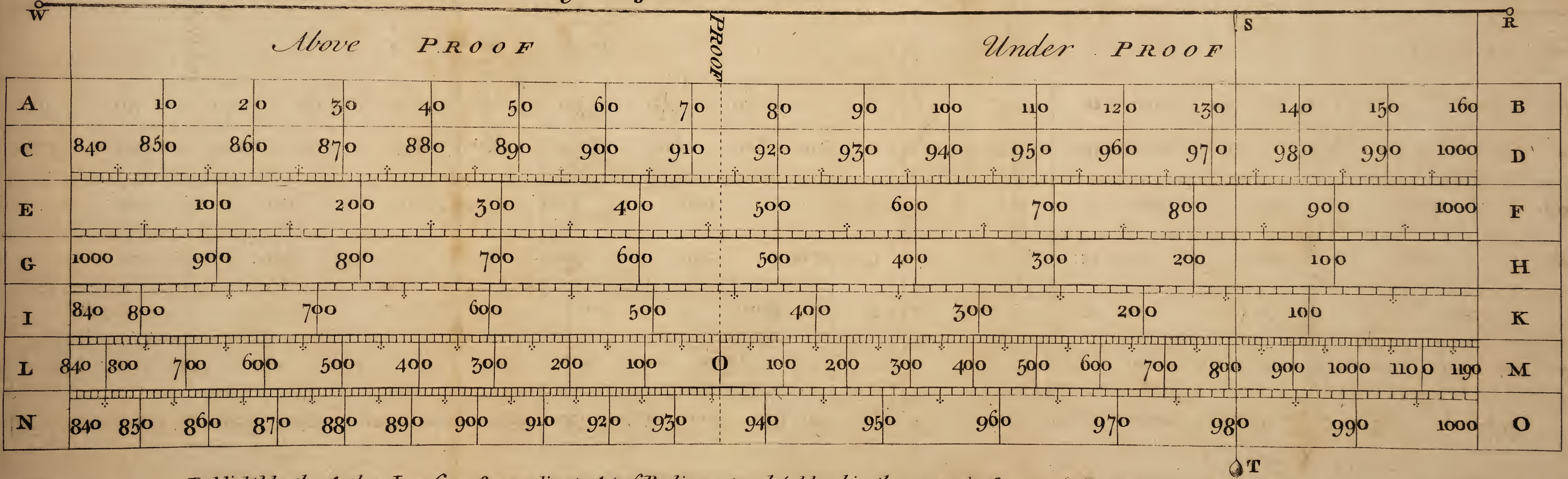
II. *Of the* WEIGHTS *uſed with this* HYDROMETER.

11. Having thus deſcribed the ſeveral Lines of this new Scale, it will be neceſſary in the next Place to give an Account of the Weights uſed with the *Hydrometer*. Theſe are nine in Number; *viz.* 400, 300, 200, 100, and 40, 30, 20, 10; with a *Proof-Weight* 600. With the four Firſt any Number of *Hundreds* under a Thouſand may be made, and with the four laſt you have any Number of Tens under an Hundred. So that with theſe eight Weights any Number

The Description and Use of a New constructed HYDROMETER or SPIRIT-PROVER *for discovering very accurately the Proportion of* SPIRIT *and* WATER *in any Composition, and how to make it Exactly* Proof,

By BENJ: MARTIN *Fleet Street London.*





W
S
R
Above PROOF
PROOF
Under PROOF
A 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 B
C 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000 D
E 100 200 300 400 500 600 700 800 900 1000 F
G 1000 900 800 700 600 500 400 300 200 100 H
I 840 800 700 600 500 400 300 200 100 K
L 840 800 700 600 500 400 300 200 100 0 100 200 300 400 500 600 700 800 900 1000 1100 1190 M
N 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000 O
T

Publish'd by the Author Jan: 16 1758 according to Act of Parliament; and Sold at his Shop opposite Sergeant's Inn Fleet Street London.

under a Thouſand may be put into the Cup (to ſhew the ſpecific Gravity of the compound Spirit) except the *Ten Digits.*

12. Theſe Digits are marked on the Stem of the Hydrometer under the Cup, in a ſmall Scale (0, 1, 2, 3, 4, *&c.*) for the Weight of the Fluid equal in Bulk to that Part of the Stem is a 100dth Part of the whole, and therefore equal to ten Parts of 1000. Hence any Number under 1000 is immediately formed by the Weights in the Cup, together with the Number on this Scale which ſtands at the Surface of the Fluid.

13. The *Proof-Weight* is marked 600; becauſe in the Line N O, the Number correſponding to the Proof-Point is 936; and this Number 936 in the Line C D anſwer to 600 in the Line of Weights E F. Hence it appears that the Vulgar ſpecific Gravity of *Proof* is to the True as 913½ to 936; and the *common* to the true *Proof-Weight* as 456 to 600.

III. *The* USE *of the* HYDROMETER, *in Compounds of a given Meaſure.*

14. When any compound Spirit is propoſed for Trial of Proof, let the *Proof-Weight* 600 be placed in the Cup, which, if it keeps the Inſtrument ſuſpended to the Point (0) on the Stem, or very near it, ſhews that Compound is *true Proof-Spirit.* But if that Weight proves too heavy, and

ſinks the Inſtrument down to the Cup, it ſhews that Compound is *above Proof.* As on the contrary, if that Weight be too light, ſo as not to carry the Hydrometer with any Part of its Stem below the Surface of the Fluid, it ſhews the Compound is *below Proof.*

15. But to ſpecify its Uſe more particularly: Suppoſe the Weight put into the Cup be 300, which ſinks the Hydrometer juſt to (0). Then it appears (1.) that the Compound is *above Proof.* (2.) That its ſpecific Gravity in the Line C D is 888. (3.) This Number muſt be ſought in the Line N O. (4.) And above it in the Line E F correſponds the Number 230, which expreſſes the Quantity of Water. (5.) And in the Line G H the correſponding Number expreſſing the Quantity of Spirits is 770. So that if the whole Compound be divided into 1000 equal Parts, the Quantity of Water is to that of Spirit as 230 to 770. (6.) In the Line I K the Number anſwering to 888 is 653; whence the Weight of Water is to that of Spirit as 230 to 653. (7.) Laſtly, in the Line L M, the Number anſwering thereto, is 426, which is the Quantity of Water to be added, to make the Compound *juſt Proof.*

16. To render this Matter ſtill eaſier to be underſtood: Suppoſe the above mentioned Compound were in Quantity juſt one *Ton*, or 252 *Gallons*, which contain 1008 *Quarts*: if we neglect the 8 Quarts as inconſiderable,

then the Numbers in the Line E F will be *Quarts*; therefore in a Ton of ſuch Spirits there will be 230 *Quarts of Water*, and 770 *Quarts of pure Spirit*; and 426 Quarts of Water muſt be added to make the whole *Proof*.

17. For a ſecond Example, ſuppoſe a Ton of ſuch Spirits as require the Weight 753 to ſuſpend the Hydrometer, that is, 750 in the Cup, and 3 on the Scale at the Surface of the Fluid. Then (1.) the Compound appears to be *below Proof*. (2.) The Number in the Line C D anſwering to that Weight, is 960½ (3.) This Number being found in the Line of *correct ſpecific Gravity* N O, is to be noted. (4.) For above it in the Line E F correſponds the Number 665, and ſo many *Quarts of Water* are in the Compoſition. (5.) Therefore the Number 335 in the Line G H, expreſſes the Quarts of Spirit. (6.) In the Line I K the Number anſwering is 283; therefore the Weight of Water is to that of the Spirit as 665 to 283. (7.) In the Line L M the Number is 450, and ſo many *Quarts of Spirit* muſt be added to make the Compound *Proof*.

18. It is eaſy to underſtand that for a *Hogſhead* of Spirits, the Numbers of the Scale will be Half-Pints, becauſe 63 Gallons contain 1008 Half-Pints. But the Quantity of the Fluid, be it more or leſs, is at any time known by *Gauging*; let this be reduced to *Quarters of a Pint*, which divided by

1000, give a decimal Number, which multiplied by the proper Numbers in the Lines of the Scale, will give the *Proportion of Water and Spirit to a thouſandth Part of a Quarter of a Pint*, which is a greater degree of Preciſeneſs than can ever be neceſſary. I ſhall give an Example or two, to render this Matter eaſy to be underſtood.

19. Suppoſe you have 3,36 Gallons of Spirit, which reduced to *Quarters of a Pint* make 107,52; this divided by 1000 gives 0,10752 for the *thouſandth Part* of the Whole. Now if we ſuppoſe it of the ſame Strength as in Article 15, then 230 of thoſe Parts will be Water, that is 0,10752 multiplied by 230, will give 24,7296 Quarters of a Pint, that is 24 Quarters, and 7296 Parts of 10000 of another. The Quantity of Spirit, therefore, muſt be 82,7904 Quarterns. And the Water to be added to make it Proof muſt be 0,10752 multiplied by 426, or 45,803 Quarterns, ſo that the Whole will ſtand as below.

	Quarterns.
Quantity of Water in the Compound ——	24,7296
Quantity of Spirit —	82,7904
Additional Water for Proof	45,803
Whole Quantity Proof —	153,3230
Reduced to Gallons —	4,7912

20. For another Example, ſuppoſe you had 13,5 Gallons of Spirit under Proof, the ſame as that in Article 17. This reduced to Quarters of a Pint make 432, which divided by 1000, gives 0,432 for a *thouſandth Part of the Whole*; then proceeding as above, we have

0,432 multiplied by 665 is equal to 287,28 Quarterns of Water.

which ſubducted from 432, leaves 144,72 Quarterns of Spirit.

Then 0,432 multiplied by 450, gives 194,4 Spirit to be added.

The whole Quantity Proof is 626,8 Quarterns

And thus you proceed with the utmoſt Eaſe and Exactneſs for any other Quantity, of any given Strength.

IV. *The* USE *of the* HYDROMETER *in a Compoſition of a known* WEIGHT.

21. When the WEIGHT of the Liquor can be conveniently taken, it will ſtill be more eaſy to determine the *additional Weight* of *Water* or *Spirit* to make it *Proof*, ſince by the Lines E F and I K, you have always the Proportion of the Weight of Water and Spirit in the given Compound; let the *ſpecific Gravity* and *Quantity* of the whole be as they will.

22. For Example; ſuppoſe you have juſt 100 Weight of ſpirituous Liquor, and find

its Strength by the *Hydrometer* to be as in Article 15. Then the Weight of the Water to that of the Spirit is as 230 to 653; add theſe Numbers together, and the Sum is 883; but the Weight of the whole Compound is 100 lb.; therefore ſay by the Rule of Three, as 883 is to 100 lb. ſo is 653 to 74 lb. the Weight of the Spirits; conſequently the Weight of Water muſt be 26 lb. (for both together make 100 lb.) Therefore ſince in Proof Spirit, the Weight of Water and Spirit is the ſame, 'tis evident 48 lb. of Water muſt be added to the Compound to make it *juſt Proof*; and then the Weight of the Whole will be 148 lb.

23. Or a ſhorter way ſtill is to take the Difference of the Numbers 653 and 230, *viz.* 423; then ſay as the total Weight 883 lb. is to 100 lb. ſo is the Difference 423 lb. to 48 lb. of Water to be added for Proof, as before.

24. Again; ſuppoſe 357 lb. of a Compound in the ſame Degree under Proof as in Article 17. wherein the Weight of Water is to that of Spirit as 665 to 283; the Sum of theſe Numbers is 948, the Difference 382. Therefore ſay, as the Sum 948 is to the Difference 382, ſo is the Weight of the whole 357 lb, to 143,85 lb. the Weight of Spirits to be added to the Compound to make the whole Proof. Hence alſo you find that the Compound itſelf conſiſted of 250½ lb. of Water, and 106½ lb. of Spirit.

And thus you proceed for any other ſpirituous Compoſition.

25. If the Quantity be large, it will be ſufficient to take the Weight in *Pounds*; if ſmall, the Weight may be taken in *Quarters of Pounds*; and if the Numbers be wrote in *Decimals*, you will have the Weight of the Spirit and Water expreſſed to the *thouſandth* Part of a Quarter of a Pound; but in general, it will be ſufficient to work by the *Sliding-Rule*, as it is both expeditious and exact.

26. In what we have ſaid hitherto, it is preſumed that the Perſon who uſes this Hydrometer is ſkilled in Fractions both Vulgar and Decimal; but if it happens otherwiſe, I ſhall next ſhow how any Perſon, without underſtanding Arithmetic at all, may uſe this Inſtrument to the greateſt Exactneſs. Thus let him find the Number of Weights that will ſink the Hydrometer to (0), and ſeek that Number in the Line E F, which for Example let be 830. The correſponding Number in the Line C D above is 973 nearly, this Number muſt be ſought in the loweſt Line N O; and exactly over it in the Line E F is 775, and in the Line I K, is 192; therefore the Weight of Water to that of Spirit in ſuch a Compound is as 775 to 192, as is evident from Articles 6, and 15.

27. Having thus found the Proportion of Water and Spirit in round Numbers 775 and

192, let theſe be added together and their Sum will be 967, alſo take the leſſer Number from the greater, and the Difference is 583; now theſe Numbers ſhow, that to every 967lb. or Ounces of the Compound there muſt be added 583lb. or Ounces of Spirit to make it Proof, becauſe then the Weight of Spirit will be equal to the Weight of Water; for 583 and 192 make 775.

28. And as nothing can be eaſier than to weigh off any Number of Pounds or Ounces from any Compound, ſo it may be immediately made Proof without the leaſt Difficulty or trouble in this laſt Method, to any one that can but count the Diviſions in a Line of equal Parts.

29. In the Uſe of this Scale, I would adviſe to have it paſted on a Board, and a Wire W R fixed over it on the Top, parallel to the Lines on the Scale, and upon this Wire let a Line and Plumet S T be put, which may be moved to any Diviſion of a Line, and then the Thread will ſhow the Numbers in the other Lines correſponding thereto, and ſo will render the whole Proceſs practicable with the utmoſt Eaſe.

V. *The Uſe of the* HYDROMETER *by taking the* DEPTH *of the* FLUID.

30. The Uſe of the HYDROMETER in Fluids of a known Depth, for thoſe who

do not underſtand Numbers, or would chuſe to be very expeditious and exact at the ſame Time, is in the following Method. Let a Veſſel be provided of a uniform or equal Figure throughout, and therein pour the ſpirituous Compound, till the Depth of it be juſt 10 Inches, then by the HYDROMETER find the *correct ſpecific Gravity* in the Line N O as before directed, and the Numbers in the Line L M above, will ſhew the Height in Inches, and thouſandth Part of an Inch, to which the Fluid muſt be rais'd, by pouring in *Water* if above Proof, or *Spirit* if below.

31. For Example, let the Compound be that of Article 26, whoſe ſpecific Gravity is 973 in the Line N O, correſpondent to which in the Line above L M, is the Number 6,75, which ſhews that the Fluid muſt be rais'd 6$\frac{3}{4}$ Inches, by pouring in Spirits, ſo that the whole Depth of the Fluid when Proof, will be equal to 16 $\frac{3}{4}$ Inches.

32. For a ſecond Example, we take the Compound of Article 15, whoſe ſpecific Gravity is 888, which being found in the Line N O, and the Number anſwering to it in the Line L M is 426, which ſhews that 10 Inches Depth of that Compound, muſt be rais'd 4 $\frac{1}{4}$ Inches, or rather four Inches and $\frac{26}{100}$ of another, by pouring in

Water to make it Proof, ſo that the Proof Spirit now will be 14 Inches $\frac{26}{100}$ deep, and theſe two Examples we preſume are ſufficient to illuſtrate this Method, which is ſo very eaſy by plain Scale and Compaſſes.*

VI. *To make any Compound* PROOF *by the* HYDROMETER *only*

33. But if it ſhould happen that none of the foregoing Methods ſhould be underſtood or thought eaſy in Practice, there is one other yet remaining, which is by Means of the *Hydrometer* itſelf and its Proof Weight only, and as this appears ſo ſimple, eaſiy, and natural a Method, it may be wonder'd why I did not mention it as the firſt, inſtead of the laſt Method to be uſed, but the Reaſon of this will appear by and by. The Praxis is this, place the proof Weight on the *Hydrometer*, and then immerſe the *Hydrometer* in the given Compound; if it be below Proof, the Weight will not ſink it to the firſt Diviſion (o) on the ſmall Scale of the Stem; in this Caſe, Spirit muſt be poured in till the Proof Weight will ſink it juſt to that Point, but in doing of this, conſiderable Time will

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* *N. B.* The Reaſon of this Proceſs depends on this Conſideration, that the Height of Fluids is always proportion'd to their Quantity in Veſſels of an uniform Figure, and therefore the Line L M will equally ſhew both.

be requir'd; for in pouring Spirits to the Compound, a certain Degree of Warmth will be produc'd in that Mixture, and you will be oblig'd to ſtay till that is gone off, or till the Fluid has acquir'd the common Temperature of the Air, before you can try the Experiment. And the Caſe will be the ſame, if the Compound be above Proof, where it will be neceſſary to put in as much Water as will make it Proof; and becauſe in each Caſe, you muſt wait for the cooling of the Fluid, and becauſe more than one Trial may be neceſſary for making it Proof, therefore you may be oblig'd to wait a longer Time than can in many Caſes be allow'd; whereas any of the foregoing Methods are very expeditious to the ingenious Compounder; but where there is time enough, this Method by the *Hydrometer* alone, without any Scale or Numbers will be very exact, and preferable to all others.

VII. *The Uſe of a* TERMOMETER *in Conjunction with the* HYDROMETER.

34. All we have hitherto ſaid is upon Suppoſition that the Air is of a *moderate Warmth*, or that the *Thermometer* ſtands at *temperate*. If the Air be very hot or very cold it will conſiderably alter the ſpecific Gravity of the Spirit. Heat will leſſen it, and therefore

make the ſpirituous Compound appear more above *Proof* than it really is. On the contrary, Cold condenſes the Compound and makes it ſeem lower than it is. And though this Difference in Weight from Heat and Cold is not very conſiderable in ſmall Quantities of Liquor, yet in large ones the Caſe is otherwiſe, and will amount to a proportional Value.

35. The *Thermometer* to be uſed is that of *Farenheit*'s Conſtruction, wherein the freezing Point is at 32, temperate at 55,* and the greateſt Summer Heat at 85 or 90. And by Experiments I have found the Numbers which anſwer to every Part of the Scale of the *Thermometer*, and have placed them on the left Hand Side beginning at (0) oppoſite to 55 or *temperate*; ſo that when the Mercury ſtands above that Point you obſerve what Number on the left Side anſwers to it, and ſo many Weights muſt be added *to the Number in the Cup*; but if the Mercury ſtands below 55 or temperate, then the Number anſwering to it on the left Hand is to be *ſubducted from the Weight in the Cup* in order to have the *true ſpecific Gravity*.

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* I take the temperate Point to be that at which the Mercury ſtands, when we ſay the Air is neither *Warm* nor *Cold*; and this I find by Experience, is generally 55 in *Farenheit*'s Scale.

36. For Example, ſuppoſe the Weights put into the Cup were 830 (as in Article 26) and the Mercury in the *Thermometer* be at 40, then oppoſite to it is 36, the Number to be ſubtracted from 830; and the Remainder will be 794, then moving the Thread to 794 in the Line E F, it will cut the Number 967 in the Line C D. Then removing the Thread to the Number 967 in the Line N O, it will cut 720 in the Line E F for the Weight of Water, and 237 in the Line I K for the Weight of Spirit; the Sum of theſe Numbers is 957, and the Difference 483, which ſhews that to every 957lb. or Ounces, there muſt be added 483lb. or Ounces of Spirit, to make the whole Proof. And therefore 967lb. will require the Addition of about 490lb. of Spirit for Proof, which is leſs than 583lb. by 73lb. And hence you ſee the Reaſon of having Regard to the *Thermometer*. *See Article* 27.

37. On the other Hand, ſuppoſe the Air very warm, and that the Mercury ſtands at 75, then oppoſite to it is 50, the Number to be added to 830 (in the Example of Article 26.) the Sum is 880, over which hang the Thread, and it will cut 981 in the Line C D; then remove the Thread to 981 in the Line N O, and it will cut 840 in the Line E F for the Weight of Water; and 137 in the Line

IK for the Weight of Spirit in the Compound. Then the Sum of thoſe Numbers is 977, and the Difference 703; therefore to every 977lb. muſt be added 703lb. of Spirit for *Proof*; conſequently to 967lb. there will be required about 695lb. that is 112lb. of Spirit more will be neceſſary for *Proof* than would have been thought of without the *Thermometer*.

38. I ſhall conclude with only obſerving, that as a Gallon of Water weighs 132 Ounces, a Gallon of Spirits ought to weigh 111 Ounces; and then it will be found that a Gallon of *Proof* will weigh 120,65 Ounces. Conſequently a Ton of real *Proof* (or 252 Gallons) will weigh 30403,8 Ounces. But by the *Statute Law* a Ton of *Proof* Spirit or 252 Gallons muſt weigh 17 Cwt. 1qr, 21lb. or 31248 Ounces, which is more than the *true Proof* by 844 Ounces or 52lb. I ſubmit this to be conſidered of by thoſe who may find themſelves intereſted in ſo great a Difference as 52lb. in 1953.

THE
MATHEMTICAL THEORY
AND
PHILOSOPHICAL PRINCIPLES
ON WHICH THE
CONSTRUCTION and USE
OF THE
HYDROSTATIC Scale of Lines
Pertaining to this
NEW HYDROMETER
DEPEND.

THE THEORY OF THE NEW HYDROMETER DEMONSTRATED

From the PRINCIPLES of GEOMETRY and HYDROSTATICS.

1. IN order to be very accurate in the Experiments neceſſary for a juſt Conſtruction of this Inſtrument, I choſe a hollow Glaſs Globe with a ſmall Hole, and having equipoiſed it in a fine Ballance, I

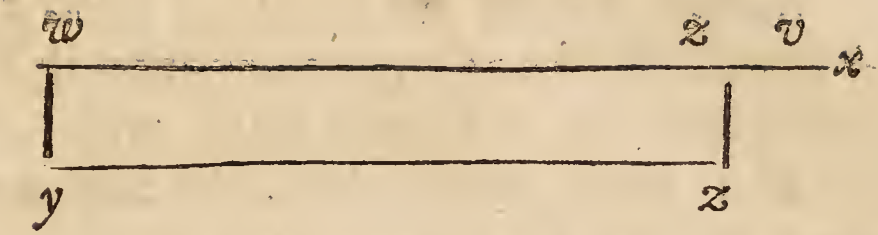
fill'd it with Water, the Weight of which was 542 Grains. The Weight of the ſame Globe of Spirit was $458\frac{1}{2}$; then $542 : 458\frac{1}{2} :: 1000 : 845$, very nearly.

2. Afterwards I took a ſolid Glaſs Globe, and making an *Equilibrium* in the Air, it was immerſed in Water, and the difference of Weight was 470 Grains; upon immerſing it in Spirits, the Difference was 397; then $470 : 397 :: 1000 : 844{,}6$.

3. The Experiments were many times repeated, but with little Variation; and as I found ſome Spirits were more highly rectified, and gave a different Ratio from that of $1000 : 845$ to $1000 : 835$; I took the mean Ratio, *viz.* $1000 : 840$, as moſt proper for the Standard for the *Hydrometer*; and here it is to be obſerved, that no Spirit was uſed but ſuch as would burn all away, and leave no Appearance of Phlegm or Water behind.

4. Let the *Bulk* of Water in any Compound Spirit be denoted by A, and that of the Spirit by B; and let a and b denote their ſpecific Gravities, *viz.* let $a : b :: 1000 : 840$. Alſo let c be the ſpecific Gravity of any Compound, whoſe Bulk will be $A + B$.

5. Fur-



5. Furthermore, let a (the ſpecific Gravity of Water) be repreſented by the right Line $w x = 1000$, and b by the right Line, $w z = 840$. And ſince the ſpecific Gravity of the Compound muſt ever be between both, let $c = w v$ denote it.

6. And ſince the abſolute Weight of any Body is in proportion to its Bulk and ſpecific Gravity, therefore the Weight of Water in any Compound will be as $a A$; and that of Spirit as $b B$; and that of the Compound as $c \times \overline{A + B}$; and conſequently we ſhall have $a A + b B = c \times \overline{A \times B}$; whence $A a - c A = c B - b B$, which gives this Analogy $A : B :: c - b : a - c$.

7. But in regard to the foregoing Line of ſpecific Gravities, we have $c - b = w v - w z = z v$; and $a - c = w x - w v = v x$. Therefore in the Compound, the Bulk of Water will be to the Bulk of Spirit as A to B, or as $z v$ to $v x$; ſince $A : B :: c - b : a - c :: z v : v x$.

8. Let W expreſs the abſolute Weight of Water, and w that of Spirit; and then $W : w :: a A : b B$ and ſo $W b B = w a A$; therefore $A : B :: W b : w a$. And in equal

Bulks, where $A = B$, we have $W b = w a$; and in that Caſe $W : w :: a : b$. Alſo if W be repreſented by the ſame Line with A, or $A = W$; then will $b B = a w$ and $w = \frac{b}{a} B = 0,84 B$.

9. In Proof-Spirit, where the Weight of the Water and Spirit is the ſame, we have $A a = b B$; and ſo $A : B :: b : a$; and therefore (by *Article* 6,) $b : a :: c - b : a - c$; whence $a b - b c = a c - a b$, and thence $\frac{2 a b}{a + b} = c =$ ſpecific Gravity of the Compound.

In any Compound that is *above Proof*, the Bulk of Water (A) is deficient by a Quantity (x) which is to be added thereto, to make it *Proof*. In which Caſe $A + x : B :: b : a :: 0,84 : 1$; therefore $A + x = 0,84 B$; and $x = 0,84 B - A$. Now 'tis evident, when $x = 0$, the Compound is *Proof*; and when $A = 0$, $x = 0,84 B =$ the greateſt addititious Quantity of Water.

11. Again, when the Compound is *under Proof*, the Bulk of Spirit (B) is deficient by a Quantity (y) to be added to the Compound to make it *Proof*. For $A : B + y :: 0,84 : 1$. in that Caſe; and therefore $A = 0,84 B + 0,84 y$, and ſo $y = \frac{}{0,84} - B$. In this Caſe alſo when $y = 0$, then the Compound is *Proof*; and when $B = 0$, the Value of y is greateſt of all, or $y = \frac{A}{0,8} = 1,19$.

12. What we have now premiſed would compleat the Theory of the *Hydrometer*, where the *Algebraic Proof* (in *Article* 9) the ſame in Fact or Reality as it is in Theory; but ſince Experience ſhews the contrary, it will be neceſſary to inveſtigate a proper Correction of this *theoretical Proof*.

13. According to the Theorem $\frac{2ab}{a+b}=c$, we ſhall have $\frac{1680000}{1840} = 913,5 =$ ſpecific Gravity of the *Proof*, but upon mixing equal Weights of Spirit and Water, and taking the ſpecific Gravity of ſuch a Mixture, by the *Hydroſtatic Ballance*, we ſhall find it conſiderably more than $913\frac{1}{2}$. Upon many repeated Trials in various Methods, I have found it to be extremely near 936; and therefore I have fix'd that Number for the *Sandard ſpecific Gravity* of PROOF; to which alſo the Number 600 correſponds in the Line E F, for the true or correct PROOF WEIGHT.

14. From hence it is evident, that in, all ſpirituous Compoſitions, which are above real Proof, ſuch Numbers muſt be inveſtigated as will expreſs the ſpecific Gravity thereof, while the real Denſity is increaſing above that given by the Theory from the Ratio of Equality in the Beginning, to that of 936 to $913\frac{1}{2}$ in that which is Proof. After this the Numbers of

the *correct ſpecific Gravity* muſt every where duely expreſs the decreaſing Denſity of the Compound under Proof in the Ratio of $\frac{936}{913\frac{1}{2}}$ at Proof to that of Equality at laſt. This proved a difficult and troubleſome Taſk, but as it was neceſſary, I undertook and compleated it.

15. From this Theory, the Conſtruction of the Scale of Lines immediately flows, *viz.* the Line A B ſhews the Number of Diviſion contain'd in the Difference $z\,x$ between the ſpecific Gravities $w\,x$ and $y\,z$ of Water and Spirit; that is, ſuppoſing $w\,x = 1000$, then $z\,x$ or $AB = 160 = 1000 - 840$. (See *Article* 5.)

16. The Line C D is the Continuation of the Diviſion of $w\,x$ from z at 840 to x at 1000, the End. Expreſſing the ſpecific Gravity of any ſpirituous Mixture in the ſame Diviſions or Numbers according to the Algebraic Theory. (See *Article* 6.)

17. The Line E F anſwers to the Line $z\,x$ divided into 1000 equal Parts; and the Line G H being the ſame but number'd the contrary way, it is evident if the Number in one repreſent the *Bulk of Water*, thoſe in the other muſt expreſs the *Bulk of Spirits* in any given Compound. (*Article* 7.)

18. The Numbers of the Line I K are thoſe of the Line G H multiplied by 0,84,

and therefore if the Numbers of the Line E F repreſent the Weight of Water, thoſe of I K will expreſs the Weight of Spirit in the Compound by *Article* 8 of this Theory.

19. The Numbers in the firſt Part of the Line L M are the Values of the addititious Quantity of Water to reduce to *Proof* all ſpirituous Compoſitions that are *above it*, calculated from the Theorem in *Article* 10.

20. The Numbers in the other Part of the ſaid Line L M beginning from the Proof Point, are the Values of the Quantities of Spirit to be added to any Compound *below Proof* to make it *exactly Proof*; and are computed from the Theorem in *Article* 11. foregoing.

21. The Numbers in the Line N O expreſs the *correct* or true ſpecific Gravities of all Compoſitions, and are only thoſe of the Line C D qualified, to repreſent the ſpecific Gravity of all *above Proof*, encreaſing from the Beginning to the *Proof Point* in ſuch a Manner that zv might in this Line contain 936 Parts in the ſame Space it contain'd $913\frac{1}{2}$ in the Line C D, and that the remaining Part vx might contain the Complement 64 to a 1000; according to *Articles* 7, 13 and 14.

22. Thus I preſume the *Rationale* of the Conſtruction of this Scale of Lines is

ſufficiently demonſtrated, and evident to every competent Judge. And I ſhall only deſire it may be obſerved, that only ONE *Inſtrument* of this Kind *can be right or true*; becauſe I take it to be a very plain Axiom, *That if one* HYDROMETER *is in its own Nature truly adapted to expreſs the real Specific Gravity, and true Proportion of Bulk and Weight in the Water and Spirit of any Compound propoſed, another Hydrometer that is of a different Conſtruction cannot do the ſame Things*, therefore, *cannot be true or juſt, but muſt be the Reſult of tentative and falacious Principles.* I could ſay much more on this Head, but the above Remark is at preſent ſufficient.——*Verbum ſat Sapienti.*

FINIS.

THE THEORY OF THE GENUINE HYDROMETER,

Farther illuſtrated,

And rendered Universal,

For determining

The Proportion of the Quantity and Weight of Alchohol and Water in any ſpirituous Compound:

AND

What Quantity of one or the other muſt be added, to make it either True or Merchantable Proof;

AS ALSO,

Proper Tables for ſhewing the ſame, by Inſpection, to the greateſt Accuracy.

LIKEWISE,

A Table to render this Hydrometer compleatly Uſeful for aſſaying all Mineral and Salt Waters, Chemical, Medicinal, and other Liquors.

PART II.

By Benjamin Martin.

LONDON:
Printed for the Author, and Sold at his Shop, the Sign of *Hadley's Quadrant*, and *Viſual-Glaſſes*, in *Fleet-Street*.

THE
THEORY
OF THE
GENUINE HYDROMETER,
FARTHER ILLUSTRATED.

1. AS I find by Experience the Lines of the *Hydrometric* SCALE are not ſo generally and eaſily underſtood as I expected, and could wiſh them to be, and in Conſequence thereof, the Uſe of this *new and genuine Hydrometer* is not ſo intelligible, and therefore not ſo much encouraged as it really deſerves; I have thought it neceſſary to give a further Illuſtration of the Nature and Uſe of this Inſtrument, by ſuch Draughts and Repreſentations, as, I hope, will render it a Matter of the utmoſt Facility. And that no Difficulty or Deficiency may poſſibly remain, or be objected, I have added a Table, to ſhew by Inſpection the Quantity or Meaſure of Alchohol or Water that is requiſite to be added to any Compound, to make it exactly either REAL or *Merchantable* PROOF.

2. The fundamental Experiment on which the Nature and Conſtruction of a GENUINE HYDROMETER depends, is this; I took a Glaſs Tube A E F K (Fig. I.) having an equal Bore throughout; into which I put a *Cubic Inch of Water*, which filled it to the Height D G; upon this I gently pour'd a *Cubic Inch* of Spirit or Alchohol, which (being a refined *Oil)* did not of itſelf mix with the Water, but ſtood above it to the Height of D B equal to D E.

3. But upon inverting the Tube ſeveral times, and thereby cauſing the two different Liquors to mix, I obſerved when they were thoroughly mix'd, and the Tube held upright, that the Compound of the Spirit and Water did not fill the Tube to the ſame Height B E, as at firſt when ſeperate, but ſubſided to the Height E C only; from whence I collected, that the Matter of thoſe Fluids did mutually penetrate each other's Interſtices, and thus occupying a leſſer Space, did conſtitute a Compound of greater Denſity than is given by a *Mathematical Theory*, which ſuppoſes the Alchohol and Water to poſſeſs the ſame Space B E F I after Mixture as before.

4. And ſince equal Quantities of Matter of two different Subſtances mixed together, produce a Compoſition that is a real MEAN between them both; this with regard to *Alchohol* and *Water*, muſt be that which is properly meant by what is call'd PROOF, and is therefore a moſt certain, fix'd, and determinate Idea; and conſequently a *Standard Meaſure* for the ſtrength of Spirituous Liquors or Compounds.

5. To aſcertain the *real Specific Gravity* of PROOF SPIRIT, we have aſſumed that of Water to Alchohol as 1000 to 840 (as found by Experiments) then the Mathematical

thematical ſpecific Gravity of equal Weights of theſe will be 913 $\frac{1}{2}$, but the real ſpecific Gravity will be greater, as we have ſhewn. In order to determine which, I put equal Weights of Water and Alchohol into the Tube, and let B I and C H be the Surfaces of theſe Fluids before and after Mixture. Then having graduated a Scale A B (Fig. 3.) into 1000 equal Parts, in ſuch Manner that the Surface C H correſponded to the Diviſion 913 $\frac{1}{2}$ in the Scale, I obſerved that the Surface B I correſponded to 936, and was thereby aſſured that the real Denſity of PROOF was to that by Theory only, as 936 to 913 $\frac{1}{2}$. This is here propoſed as an ocular Demonſtration, and is more accurately confirmed by the HYDROSTATIC BALLANCE.

6. Let a g d (Fig. 2.) be a Triangle whoſe Side g d is equal to the Line A B (Fig. 3.) of 1000 equal Parts, and take g c = 840 of thoſe Parts; then draw b c parallel to a d; and ſince it is g d : g c : : a d : b c : : 1000 : 840, therefore the Lines a d and b c will repreſent the ſpecific Gravities of Water and Alchohol. Thus *Air*, *Cork*, *Saſſafras Wood*, *Fir*, *Cedar*, *Æther*, and other Bodies, whoſe ſpecific Gravities are leſs than that of Water, may have their Places aſſign'd in this *Triangular Scale*, according to their ſpecific Gravities in the Line A B.

7. Since the Figure or Space a b c d is that which comprehends all the ſpecific Gravities between Spirit or Alchohól and Water, let this be repreſented more at large, as in the Trapezium A B C D (Fig. 4.) where parallel Lines drawn through every 10 Degrees of ſpecific Gravities between 840 and 1000 will repreſent the ſpecific Gravities of all the various Compounds of thoſe Degrees between that of Alchohol 840 = B C to

that of Water A D = 1000. Thus the Parallel b i will repreſent the Denſity or ſpecific Gravity of *Proof Spirit*, as it is drawn from 913 $\frac{1}{2}$.

8. Theſe Parallels repreſenting the ſpecific Gravities, will alſo, when properly divided and ſubdivided by Lines drawn in the Figure, denote by their Parts, the Ratios of the Bulk and Weight of Water and Alchohol in any given Compound, and alſo the Meaſure or Quantity of Water or Spirit that muſt be added to make it perfect PROOF.

9. Thus by drawing E B parallel to D C, the Parts of the Parallels between thoſe two Lines being every where equal, do repreſent any given Meaſure of a ſpirituous Compound, from all Alchohol at B C, to all Water at E D, whether this Meaſure be a *Pint*, a *Gallon*, a *Hogſhead*, or a *Ton*.

10. Again, a Line drawn from B to D diagonally, divides theſe equal Parallels into unequal Parts, of which thoſe towards E B repreſent the *Bulks of Water*, and the other Parts toward D C the *Bulks of Spirit* in a given Compound; thus let the Compound be h e whoſe ſpecific Gravity is d e = 936, the Quantity of Water will be to that of Spirit, as h g to g e. Alſo let a i be a Parallel of compound PROOF, whoſe ſpecific Gravity is b i = 913 $\frac{1}{2}$, then the Quantity of Water will be to that of Spirit, as a f to f i.

11. In the Line B C take B m to B C as 840 to 1000, and draw the Line D m. Then will all thoſe Parts of the Parallels which before repreſented the Bulks or Meaſures of Alchohol be now curtailed or diminiſhed in the Ratio of 840 to 1000, or 0,84 to 1. And therefore if the Parts of the Parallels in the Triangle E B D be now taken to repreſent the *Weight* of Water (as before

they did the *Bulk*) then the other Parts contained in the Triangle B D m will repreſent the Weight of Alchohol in a given Compoſition, becauſe by Art. 8, of the Theory, we had $w = 0{,}84$ B, (when A = W) and conſequently 1 : 0,84 : : B : w : : g e : g n : : f i : f k; or the Weight of Water to that of Spirit in the Parallel d e, will be as h g to g n; and in the Parallel of Proof b i, the Weights of Water and Spirit will be as a f to f k, and therefore equal to each other; for by the Theory (Art. 9.) when W = w, we have A : B : : b : a; that is, a f : f i : : B m : B C : : f k : f i, conſequently a f = f k.

12. As the Weight of Water in all the Compounds between the Parallel of *Proof* a i, and that of pure Spirit B C, is leſs than the Weight of Spirit, they muſt all be *above Proof-ſtrength*, to which they are to be lowered or reduced by the addition of a certain Quantity of Water; which Quantity as it is *nothing* in the Parallel of *Proof*, and in the Parallel B C of all Spirit, it muſt have the Proportion of 0,84 to 1, or of B m to B C, (by Theory Art. 10,) therefore a Line drawn from (a) to (m) will cut off ſuch Portions of the Parallels towards a B, as will duly repreſent the additional Quantities of Water as are required for reducing the Compound to *Proof*. Thus in the Parallel *s x*, whoſe Denſity *r x* is leſs than that of Proof b i, the Ratio of the Bulks of Water and Spirit is that of *s t* to *t x*; the Ratio of the Weights, is that of *s t* to *t w*; and the Quantity of Water to be added to make it Proof is denoted by *s v*.

13. Or thus,
- sx is a given Quantity of a Compound.
- rx is its Denſity or ſpecific Gravity.
- st is the Quantity or Bulk of Water.
- tx is the Quantity of Alchohol.
- st is the Weight of Water.
- tw is the Weight of Alchohol.
- sv is the Quantity of Water required to make it Proof.

14. On the other Hand in all Compounds below Proof contained between the Parallel of Proof a i and that of all Water E D, we determine the Quantity of Spirit or Alchohol to be added to make the given Compound of *Proof-ſtrength*, by drawing the Line i A; for it begins at nothing in the Parallel of Proof at i, and in the Parallel of all Water E D, it muſt have the Proportion to the Bulk of Water E D as 1,19 to 1 (for $y = \frac{A}{0,84} = 1,19$ Art. 11 of the Theory) that is, if $ED = 1$, then $AD = 1,19$. ſince $Bm : BC :: ED\ (= BC) : AD$, or, $0,84 : 1 :: 1 : 1,19$.

15. Therefore in the Parallel h e of 936 ſpecific Gravity,

we have
- h e, the given Quantity of the Compound.
- d e, the Denſity or ſpecific Gravity.
- h g, the Quantity of Water.
- g e, the Quantity of Alchohol.
- h g, the Weight of the Water.
- g n, the Weight of the Alchohol.
- l e, the Spirit to be added for Proof.

16. The Difference between 1000 and 840 being 160, there would be ſo many Parallels in the Figure, if they were all drawn; but as they are drawn through every tenth Diviſion only, there are now but 16, (or 17 including both Extremes) of which 8 are below the *Parallel* of PROOF, and 9 above it.

If the whole Difference of 160 Degrees of ſpecific Gravity be divided into 1000 equal Parts, then the Scale A B (Fig. 3) will repreſent them; and the Point or Diviſion of the ſaid Scale correſponding to the Parallel of *Proof* will be 456,5.

17. Conſequently if the HYDROMETER be made of ſuch a Weight as will juſt ſink it in Alchohol to the firſt Diviſion, or (0) on the Stem, (or Scale of 10 equal Parts upon it,) and then afterwards a Weight be applied on the Top as ſhall juſt ſink it to the ſame Diviſion (0), in Rain or River Water, and this additional Weight be divided into 1000 equal Parts, then 456 $\frac{1}{2}$ of thoſe ſmall Parts or Weights would be the PROOF-WEIGHT, *viz.* ſuch as would juſt ſink the HYDROMETER to (0), in a Compound that is of juſt PROOF or STANDARD STRENGTH; provided the Bulks of Water and Alchohol were the ſame after Mixture as before.

18. But, as we have ſhewn, this is not the Caſe; but that the two Liquids in mixing, do ſo incorporate as to cauſe the Bulks to contract, and the Denſity of courſe to encreaſe in the Ratio of 913 $\frac{1}{2}$ to 936; therefore the Denſity d e of the Parallel of 936 will be that of the Compound when PROOF, and the PROOF WEIGHT correſponding thereto in the Scale A B (Fig. 3.) will be 600 as is evident by inſpection.

19. Hence it appears that this Fig. 4. will by no means truly repreſent the Nature and State of Spirituous Compounds, in regard to their Denſity, or ſpecific Gravity, nor the reſpective Quantities and Weights of Water and Alchohol, nor the Quantity of either to be added for making Proof; and therefore muſt be ſo altered and new modelled, that all thoſe Particulars may be duly expreſſed, and repreſented in their juſt Proportion and Quantity. And ſuch is Fig. 5. as will appear by conſidering the following Things.

20. Firſt, retaining the ſame Height C D, it is evident from what we have ſhewn, that the Line B D muſt *biſect* that Part of the Parallel of Proof which lies in the Part E B m D which it cannot do any where but in the Parallel a i, at the Diſtance C i, in the Diviſion 913 $\frac{1}{2}$; as there only a f=f k, or the Weight of Water is equal to that of Spirit.

21. Secondly, In this Parallel a i, the Denſity of the Compound muſt be equal to that at the 936th Diviſion in Fig. 4. *viz.* c i here muſt be equal to d e there.

22. Thirdly, Conſequently all the Space d e C B in Fig. 4. muſt be contracted into the Space c i C B in Fig. 5. that ſo all the Parallels below 936 may have a proper Share of the encreaſed Denſity, or the additional Part ſhewn in the ſmall Triangle c B b; for a b in each Fig. is the ſame; and a c here, equal to d h in Fig. 4.

23. Fourthly, Alſo the Space d e D A in Fig. 4. muſt here be expanded into the Space c i D A, that ſo the various Parallels above 936 may duly partake of the additional Denſities contained in the Triangle c A b.

24. Fifthly, 'Tis obvious in Fig. 4. the Denſity of the Compound encreaſes every where in the ſame Ratio with the Quantity of Water; thus *r s* : b a :: *s t* : a f; and b a : d h :: a f : h g, and ſo on. But in Fig. 5. this Ratio holds no further than the Parallel of Proof c i, becauſe here the Fig. of Denſities A c B a E is not a Triangle but a Trapezium.

25. Sixthly, Hence all the Diviſions in the Line of ſpecific Gravities from C to i will be much leſs than thoſe in the remaining Part from i to D, though every where equal among themſelves, in each reſpective Part.

26. Seventhly, The Scale A B of 1000 equal Parts, or ſmall Weights (Fig. 6.), will alſo have its Diviſions contracted as far as 600, the *Proof Weight*; and afterwards the remaining Diviſions will be dilated as *per* Figure.

27. Eighthly, By this reduction of one Part of the Figure, and Dilation of the other, it comes to paſs that the juſt Ratio or Proportion of the Quantity of Water to that of the Spirit, in any Compound, will be determined and duly expreſſed by the Parts of the Parallels in the Triangles E B D and C B D; alſo, that of their Weights by the Triangles E B D and m D B; and laſtly the Quantities of Water or Spirit to be added for Proof, by the Triangles a B m, and i A D.

28. Thus in Fig. 5.

r s is the true Encreaſe of Denſity above B C.

s t : *t x*, the Ratio of the Bulks of Water and Spirit.

s t : *t w*, the Ratio of their Weights.

s v, the Quantity of Water to be added for Proof when the ſpecific Gravity of the Compound is 880; and which are all different from thoſe in Fig. 4. (ſee Art. 13.

Of the CONSTRUCTION *of* TABLE I.

Shewing by Inſpection, the Meaſures of a given COMPOUND *to which one ſuch Meaſure of* WATER *or* ALCHOHOL *muſt be added to make it* real PROOF.

29. BY the Figures above explain'd, the Nature of a GENUINE HYDROMETER, and the Conſtruction of the *Hydrometric Scale of Lines* directing its Uſe, will, I hope, be better underſtood than they have been hitherto, but leſt any Difficulty ſhould yet remain, I have added a *large Table, for ſhewing by Inſpection, the* Gallons *of the Compound anſwering to any given Weight on the* HYDROMETER; *to which* one Gallon *of* Water *or* Spirit *is to be added to make it* true PROOF. The Rationale of the Table is this.

30. In Fig. 5. let $B\,m : B\,C :: 0{,}84 : 1 :: b : a$, and put $a\,B = 600 = p$, $a\,s = d$; and let the addititious Quantity of Water be to that of the Compound above Proof, as $s\,v : s\,x :: x : n$; then it will be $p : d :: b : x = \frac{d\,b}{p}$; but by Suppoſition $x : 1 :: A + B : n$, and conſequently $x = \frac{A + B}{n} = \frac{1}{n} = \frac{d\,b}{p}$; whence $n = \frac{p}{b\,d}$; therefore n is given by having d; and if x be expounded by 1, then n is $A + B$, or the Quantity of the Compound expreſs'd by the Numbers in the 2d Column of the Table, above *Proof*.

31. Again for Compounds below *Proof*, let D i $= 400 = q$, and i e $= r$, and d e $= y$, the addititious Quantity of Spirit; then becauſe E D : A D :: $a : c :: 1 : 1{,}19$ we have i D : i e :: A D : d e, that is, $q : r :: c : y = \frac{cr}{q}$; but alſo $y = \frac{1}{n} = \frac{cr}{q}$; wherefore $n = \frac{q}{cr}$; and if y be $= 1$, then $n = A + B$, or the Compound expreſſed by the Numbers in the 2d Column of the Table, *below Proof*.

32. The Ratio of the Bulks of Water and Spirit is known for any Value of (n) or Number in the Table, thus by Theory Art. 10. we have $A + x : B :: b : a$; therefore $\frac{Bb}{a} - A = x = \frac{A + B}{n}$, whence we get $A : B :: nb - a : na + a$, in compounds *above Proof*. And in thoſe which are below, we have $A : B + y :: b : a$; whence $y = \frac{aA}{b} - B = \frac{A + B}{n}$; and thence $A : B :: nb + b : na - b$.

33. Furthermore, the Ratio or Weight of the Water and Spirit in the Compound is hence determined; for ſince $W : w :: aA : bB$, we ſhall have $W : w :: \overline{nb - a} \times a : \overline{na - a} \times b :: nb - a : nb + b$; for all *above Proof*; and for all *below*, we have $W : w :: \overline{nb + b} \times a : \overline{na + b} \times b :: na + a : na - b$.

34. In Numbers, where $b = 0{,}84$, and $a = 1$, we have,

$$A : B \left\{ \begin{array}{l} :: 0{,}84n - 1 : n + 1 \text{ ——— above Proof.} \\ :: 0{,}84n + 0{,}84 : n - 0{,}84 \text{ — below Proof.} \end{array} \right.$$

$$W : w \left\{ \begin{array}{l} :: 0{,}84n - 1 : 0{,}84b + 0{,}84 \text{ — above Proof.} \\ :: n + 1 : n - 0{,}84 \text{ ——— below Proof.} \end{array} \right.$$

N. B. If the Ratio of A to B be given, then the Quantity (n) is given; and conſequently the Weight to ſink the Hydrometer to (o) in ſuch a given Compound: For from the Analogies (in Art. 32) we have $n = \frac{A + B}{bB - A}$ when it is *above Real Proof*; and $n = \frac{\overline{A + B} \times b}{A - bB}$ when it is *below.*

The CONSTRUCTION *of* TABLE II.

For Merchantable PROOF.

35. WE have now conſidered the *falacious Proof* given by the *Mathematical* THEORY; as alſo the *true* and *genuine* PROOF from the Principles of PHILOSOPHY; but there yet remains a third ſort of Proof to be conſidered, which is uſually called the *Saleable* or *Merchantable Proof*, being that commonly uſed in buying and ſelling Spirituous Liquors. This may be properly called an *Arbitrary Proof*, being determined and eſtabliſhed only by *Cuſtom* and Uſe.

36. This Proof reſults from aſſuming the Weight of a Gallon of it to be 124 Ounces, which is 3,35 Ounces more than the Weight of a Gallon of real Proof which is but 120,65 Ounces. Whence it appears, this *Merchantable Proof* is a Compound below TRUE PROOF in a very remarkable Degree. For ſince in given Quantities the ſpecific Gravities are directly as the Weight; therefore ſay as 120,65 : 124 : : 913,5 : : 938,9 which therefore is the ſpecific Gravity of *Saleable* Proof, by the Scale in Fig. 4. But

in the correct Scale, Fig. 5. it is 954,8, or in round Numbers 955.

37. From hence it appears by Inſpection, that if h o repreſent the Parallel of *Merchantable Proof*, then the Bulk of Water h g greatly exceeds the Bulk of Spirit g o in that Compound. And the Weight of the Water h g is near twice as great as the Weight of Spirit g n; and laſtly, the Quantity of Spirit l o to be added to make it *real Proof*, is nearly equal to all the Spirit it contains, *viz.* g o.

38. As the *Hydrometer-Weight* for REAL PROOF is 600, ſo that for *Merchantable Proof* is 714$\frac{1}{2}$; and therefore each Proof is with equal Eaſe and Exactneſs aſcertained by the *Genuine* HYDROMETER.

39. Now in order to determine the Ratio of Bulk and Weight of Water and Alchohol in the Merchantable Proof, we have (by Art. 31.) $q = 400$, $r = 117,45$, and $c = 1,19$ there $n = \frac{400}{117,45 \times 1,19} = 2,862$; and therefore A : B :: $0,84n + 0,84 : n - 0,84$ :: 3,244 : 2,022. Wherefore the Water exceeds the Alchohol by ſomewhat more than a third Part.

40. Again we have the Weight of Water to the Weight of Spirit, as $W : w :: n + 1 : n - 0,84$ :: 3,862 : 2,022, or the Weight of Water is almoſt double that of the Spirit; as we obſerved in Art. 37. Whereas in *true Proof* the Weights of both are the ſame.

41. In REAL PROOF, the Quantity of Spirit exceeds that of Water in the Ratio of 100 to 84, but in the *Merchantable Proof*, the Quantity of Water exceed that of Spirit, nearly in the Ratio of 100 to 63.

42. And therefore if we take E D : F D : : 100 : 63 : : 1 : 0,63, and draw o F, it will cut off ſuch Portions of the Parallels towards o D, as will duly expreſs or repreſent the Quantities of Spirit that muſt be added to the reſpective Compounds, repreſented by thoſe Parallels, to make them of *Saleable Proof.* Thus for the Compound of 970, the Quantity of Water is (*a c*), the Quantity of Alchohol is (*c e*), the Quantity of Alchohol to be added for TRUE PROOF is (*b e*), and that for *ſaleable Proof* (*d e*).

43. On the other Hand if B C be continued out, and we take B C : B G : : 63 : 100 : : 0,63 : 1 ; and join h G, it will determine ſuch lengths of Parallels, (continued out when there is occaſion) as will every where repreſent the Quantities of Water to be added for *Merchantable Proof.*

44. Hence the ſecond Table is made for *Merchantable Proof*, in the ſame Manner as the firſt was made for *real Proof*; and the ſame Weights of the Hydrometer ſerve equally for both. See Articles 30, 31, and 38.

The Conſtruction *of* TABLE III.

By which the HYDROMETER *is adapted to examine* MINERAL *and* SALT WATERS, Medicated *and other* LIQUORS, *to the greateſt Exactneſs, in regard to their* ſpecific GRAVITY.

45. THE *genuine* HYDROMETER is in its Nature equally well adapted to explore the ſpecific Gravities of Liquors to the ſame Extent *above*

that of River Water as *below* it, *viz.* to 160 in the Scale of 1000, Fig. 3. And as all Degrees of Denſity in ſpirituous Compounds, below Water to pure Alchohol, are contained in that Extent; ſo the Denſity or ſpecific Gravities of all *Salt*, and MINERAL WATERS, *Medicated* and *Chemical* LIQUORS, and many natural Fluids, as *Blood*, *Milk*, *Urine*, *Serum*; alſo all Kinds of prepared Liquors for domeſtic Uſes, as *Cyder*, *Perry*, *Wines*, *Worts*, *Beer*, *Ale*, *Punch*, &c. &c. are all within the reach of this Inſtrument; and as their eſſential Goodneſs and Value depends on and may be moſt eaſily aſcertained by it, to the greateſt deſirable Exactneſs, this HYDROMETER is capable of being applied to promote the greateſt Ends in MEDICINE, CHEMISTY, and *Natural* PHILOSOPHY.

46. The *Water-Weight* being put on at the Bottom, the other Weights are applied on the Top to diſcover any ſpecific Gravity from 1000 to 1160 by means of the Numbers in Table III. which are thus calculated. Let the Ratio of the ſpecific Gravity of *Rain-Water* to *Sea-Water* be that of 1000 to x, then will x be the Number in the Table required. Then as

$$1000 : 160 :: a : \frac{160\,a}{1000} = 0{,}16\,a; \text{ then } 0{,}16\,a + 840$$

$= x$, the ſpecific Gravity required; thus all the Numbers of the Table are found from 1000 to 1160.

N. B. The Value of (a) is the Sum of the *Water-Weight* 1000 at the Bottom, and the Weights put on at the Top.

The Manner of Conſtructing the Genuine HYDROMETER, *ſo as to render it Univerſal, for examining all Kinds of* FLUIDS.

47. IN Order to conſtruct a *true*, *genuine*, and *univerſal* HYDROMETER, it muſt be conſidered that the Deſign of ſuch an Inſtrument is to diſcover and meaſure the peculiar Weight, Denſity, or Strength of a given Compound, or ſimple Liquor in a *given Quantity*; which given Quantity is equal to a given and determinate Part of the Hydrometer to be conſtantly immerſed into it.

48. By this Means we know the Weight of the ſame Bulk or Quantity of different Liquids, and thereby their *comparative Denſities*, and ſpecific Gravities. Thus let all the Part of the HYDROMETER (Fig. 7.) below D be that which is to be conſtantly immerſed in the Liquor, which in the firſt Place ſuppoſe to be *Alchohol*, whoſe ſpecific Gravity compared with that of River-Water, is found by the *Hydroſtatic Balance*, to be in the Ratio of 840 to 1000. And that it is nicely balanced in ſuch a Spirit by a proper Weight or Foot at K, ſcrew'd on at the End of the Shank H I, which is ſoldered into the Ball F G, and keeps the Inſtrument in a perpendicular Poſition. Note, this Weight K is called the *Spirit-weight*.

49. But ſince Water has a greater Denſity than *Alchohol*, it will not ſink into that ſo far as D without an *Additional Weight* applied to it. This Weight is there-

fore to be found very accurately, and then divided into 1000 equal Part.

50. Then it is evident, that when this HYDROMETER is immerſed into any Liquor compoſed of Water and Spirit, a certain Weight applied to it, will ſink it therein to D, and give it an Equilibrium there. This additional Weight is equal to the Exceſs of the Weight of this Compound above that of an equal Bulk of *Alchohol*; and muſt be expreſſed in Parts of the 1000 into which the whole Difference of the Weight of Water and Alchohol was divided.

51. Now this additional Weight muſt be applied to the *Hydrometer* either on the *Top* at B *out* of the Liquor, or at the *Bottom* at I, *in* the Liquor; and it may be made to anſwer with equal Accuracy either Way. But theſe two different Methods of Application of the Weight are attended with very different Circumſtances in regard to *Conveniency* and *Diſpatch*, two principal Points in the eſſaying of ſpirituous Liquors.

52. But ſuppoſing that the Weight were applied to the Bottom, there muſt be at leaſt 100 out of the 1000 to be ſcrewed on and off the *Hydrometer*; and every Time a Weight is changed, the Inſtrument muſt be taken out, and again put into the Liquor, which Proceedure muſt neceſſarily be ſo tedious and irkſome, as to be impracticable in common Uſe; and accordingly we find that inſtead of 100 different Weights, and theſe multiplied to 1000, there are in common Practice not more than about 30 uſed for ſpirituous Compounds, and thoſe not capable of being multiplied with any Kind of Certainty or Truth.

53. But,

53. But, if the Weights are applied at the Top of the Inſtrument out of the Fluid, then all ſuch Weights may be almoſt inſtantly applied and changed, till the *Equilibrium* be procured, and the Strength of the Compound aſcertained to the 1000th Part of the Whole, and this without ever taking the Inſtrument out of the Fluid once. And as this Method admits of the utmoſt Facility, Expedition, and Exactneſs, nothing more need be ſaid to recommend it to the judicious.

54. The Weights which determine the Strength of all Compounds below Water to 160 Degrees of the Scale of ſpecific Gravities, will alſo equally ſhew as many above Water, and therefore take in all the ſpecific Gravities of Fluids from that of Water 1000, to 1160; which comprehends the ſpecific Gravities or Denſities of all MINERAL and SALT WATERS, and of moſt other natural and chemical Fluids, which therefore are all ſubject to a very critical Examination by this HYDROMETER, as they may thereby have their reſpective ſpecific Gravities made apparent to that 1000th Part of the Whole 160.

55. If the Strength, Denſity, or ſpecific Gravity of any Liquors exceed the Ratio of 1160 to 1000, this Inſtrument will find them ſtill, with the ſame Weights, and to the ſame Degree of Accuracy; for only another *Water-weight* K is required juſt double the Weight of the former, and then the HYDROMETER will explore all ſpecific Gravities from 1000 to 1320, which is farther than ever there can be Occaſion for. Since I find

by Experiment, that a Solution of Salt in Water as ſtrong as it can be made, will not exceed the Weight of Water more than in the Ratio of 1215 to 1000.

56. I need only obſerve further, that by this *genuine* HYDROMETER, you will ever be able to determine the Ratio or Proportion of the Quantity and Weight of Water, to the Quantity and Weight of Alchohol in any Compound, by Art. 32, 33, 34. But this, I preſume, you will in vain attempt with one of any other Structure.

57. As the Increaſe of the Denſity of the Compound is ever proportional to the Quantity of the heavier Ingredient, as is evident from the Triangles being ſimilar, therefore when we know the ſpecific Gravity of a *ſaline Mixture* in which a given Quantity of Salt has been diſſolved, then the Quantity of Salt in any other is alſo known from its ſpecific Gravity given by the HYDROMETER. Thus, ſuppoſe 3 Cubic Inches of River-water diſſolves one Cubic Inch of common Salt, and the ſpecific Gravity of ſuch a ſtrong Solution I find to be 1215; but taking a Quantity of *Sea-water*, I find by the Hydrometer, that its ſpecific Gravity is but 1030; then I know that its Salt, in a given Quantity of Water, is to that in the ſtrong Solution, as 30 to 215, or as 1 to 7 nearly, and conſequently that a *Pint of Sea-water* contains *one Cubic Inch of Salt.*

58. Hence it appears, how ſerviceable ſuch an Hydrometer muſt be in all SALT-WORKS, as a ſure Guide or Director in aſcertaining the various Denſities, and the Quantities of Salt contained in given Meaſures of their *Brines*. By this one Inſtance it alſo appears, how extenſive its Application may be made, as it will readily diſcover the ſpecific Gravity of all Fluids and Liquors,

quors, natural or artificial, in no leſs than 3000 different Degrees, and that with *twelve Weights* only.

The USE *of the following* TABLES *illuſtrated by* EXAMPLES.

The USE *of* TABLE I *for* true PROOF.

59. FOR the Sake of ſuch as are not acquainted with the Uſe of Lines and their Diviſions, for eſtimating Quantities, or of ſuch as would chuſe to have a greater Degree of Accuracy in their Computations, I have here added ſeveral TABLES whereby the Uſe of the HYDROMETER is rendered as eaſy as can be deſired, or, indeed, as the Nature of Things will admit of. The Conſtruction of theſe Tables has been already ſhewn, and we now proceed to exemplify their Uſes.

60. The *firſt* TABLE contains in the firſt Column the Number of Weights put upon the Hydrometer to ſink it to its proper Depth (or Point (*o*) on the Stem above the Ball) in any propoſed Compound. And the Numbers of the 2d Column ſhew the Quantity or Meaſures of that Compound to which one Meaſure of *Water* (if above Proof) or of *Alchohol* (if below) muſt be added to make the Whole *real* or *true* PROOF.

61. For EXAMPLE. Suppoſe the Weight 300 ſinks the Hydrometer to (*o*) on the Stem, in a propoſed Compound Spirit, then look for the Number 300, in the firſt Column, and againſt it in the 2d, you will find the Number 2.381, which ſhews, that to $2\frac{381}{1000}$ *Gallons* of the Compound, *one Gallon* of *Water* muſt be ad-

added to make it *true* PROOF, or 10 Gallons of Water to 23 $\frac{81}{100}$ Gallons of the Compound; or 100 Gallons to 231 $\frac{1}{10}$ Gallons; or laſtly, 1000 Gallons of Water, and 2381 Gallons of that Compound make real PROOF.

62. EXAMPLE II. For a Compound Spirit *below Proof.* Suppoſe the Weight on the Top of the HYDROMETER, which ſinks it to (3) on the Scale, be 750, then the whole Weight is 753; the neareſt Number to that in the firſt Column of the Table is 755, correſponding to which in the 2d Column is 2,168, which ſhews that *one Gallon* of *Alchohol* is to be added to 2 $\frac{168}{1000}$ Gallons of this low Compound to make it PROOF.

$$\text{Or}\left\{\begin{array}{l}10 \text{ Gallons to } 21\,\frac{68}{100}\\ 100 \text{ ——— } 216\,\frac{8}{10}\\ 1000 \text{ ——— } 2168\end{array}\right\}\text{for } \textit{true} \text{ PROOF.}$$

63. By theſe Numbers in the 2d Column, you have the Ratio of the Quantity of the Compound to that of the Water or Spirit to be added for Proof univerſally for all Degrees of Strength. And therefore if you have any given Quantity of a ſpirituous Compound, you will hence readily know the Quantity of Water or Spirit to be put to it for making it *Proof.* For ſuppoſe you have 3,36 Gallons of that Compound above Proof in Art. 62. Then ſay, by the *Rule of Three*, as 2,381 is to 1, ſo is 3,36 to 1,411 = 1 Gallon 3 $\frac{1}{4}$ Pints. The Quantity of Water to make it *Proof*; and the whole Quantity will be 4 $\frac{77}{100}$ Gallons. In the ſame Manner, 336 Gallons require 141 $\frac{1}{10}$ Gallons of Water, and then the whole Quantity made Proof is 477 Gallons.

64. By theſe Numbers in the 2d Column, we are able to *analize*, or *decompound* (as it were) any given Compound, or ſhew the Proportion of its *component Parts* in reſpect both to *Quantity* and *Weight*. For Example, let the Compound propoſed be that of Art. 63. which is *below Proof.* Where the Number 2,168 is the Value of (*n*) in Art. 33, 34; therefore the Proportion there given becomes A : B : : 2,561 : 1,168 : : Quantity of Water: Quantity of Spirit, or the Water is near twice as much as the Spirit in that Compound. And the *Weight of the Water* is to the *Weight of the Spirit* as 2,56 to 0,98. See Art. 34.

Uſe of TABLE II. *for* Saleable PROOF.

65. THE Numbers in Table II. are adapted to Computation for *Cuſtomary* or *Merchantable* PROOF, as thoſe of the firſt Table were for *true* PROOF. The Manner of Proceedure therefore is the ſame in both for finding the required Quantity of Water or Spirit to be added to any propoſed Compound Spirit, above or below *Saleable Proof*, to make it truly ſuch.

66. Since (by Art. 41, 42.) it appears, that ſaleable Proof is ſo low, or the Compound ſo weak, we may, with good Reaſon, make its *Proof weight*, 700. And according to this Proof, the 2d Table is computed, whoſe Uſe in Practice is the ſame with the foregoing. Thus find in the firſt Column the Weight which ſinks the *Hydrometer* to (o), and againſt it in the 2d Column,

is the Number of Gallons to which *one* muſt be added for making it *Merchantable Proof.*

67. For EXAMPLE. Suppoſe in a given Compound we put the Weight 300 on the Hydrometer to ſink it to (*o*) on the Scale; then againſt 300 in the firſt Column, you find 1,103 in the Second, which ſhews, that to every $1\frac{103}{1000}$ Gallons, one Gallon of Water muſt be added to bring it to be *ſaleable Proof.* Or more accurately, 10 Gallons of Water to 11 of the Compound.

68. Again, ſuppoſe the Compound ſuch, that the Weight required to ſink it to (*o*) were 665; then it appears this Compound is *above Merchant's Proof*, but below the real Proof. Againſt 665 in the firſt Column you ſee 12,61, which ſhews that one Gallon of Water is to be added to every $12\frac{61}{100}$ Gallons of the Compound for making it *Merchantable Proof.*

69. For a third EXAMPLE, let the ſpirituous Compound be ſuch that the Weight 770 is required to ſink it to (*o*), then againſt that Number you ſee 6,802, which ſhews, that to $6\frac{802}{1000}$ Gallons of the Compound, one *of Spirit* muſt be added, to bring it down to *ſaleable Proof*; or 10 Gallons of Spirit to 68 of the Compound. Theſe Examples, I think, muſt be ſufficient for every intelligent Perſon, and though I have all along made mention of *Gallons*, yet the Ratio is the ſame for *Pints*, in ſmall Quantities; or *Firkins*, *Hogſheads*, and *Tons* in large ones.

Of Arrack PROOF.

70. WITH regard to ARRACK, a great Pother has been made about Nothing; becauſe there is no Doubt to be made, but that the *Arrack-Alchohol*, as well as that from Wines, Melaſſes, Malt, *&c.* may have its ſpecific Gravity in its lower State of Purity, ſtated at 840 in Compariſon of that of Water at 1000.

71. Then it only remains to know what Proportion of Water and Arrack-ſpirit makes a common *ſaleable* ARRACK-PROOF. Dr. SHAW (*Phyſician* to his MAJESTY) tells us, that Arrack uſually contains *three Parts of Water to one of Spirit*; in this Caſe, its ſpecific Gravity is ſuch as will require the Weight 816 to be put on the Hydrometer to ſink it therein to (0). And therefore the Weight 800 may be eſteemed the proper ſaleable *Arrack* PROOF-WEIGHT.

72. Accordingly, *ſtrong Arrack* may be reckoned that which requires the Weight 750 to ſink the Hydrometer to (0), and *weak Arrack*, that which will take the Weight 850; ſo that this *Hydrometer* will indicate 100 different Degrees in the Strength of Arrack, and as many more as you pleaſe, there being the ſame Exactneſs and Facility in applying it to this Sort of Spirit as to the common ones.

The Uſe of TABLE III.

73. THE Uſe of this Table is ſo fully ſhewn in the Conſtruction of it, that little more can be added. See Art. 45. and the following ones. As the *Lightneſs* of ſome Fluids, and the *Weight* of others are the Indications of their Goodneſs, ſo the *Hydrometer* being immerſed into them, will by this Table immediately diſcover thoſe ſpecific Gravities, and thereby enable us to form a true Judgment of their *Nature, general Properties, conſtituent Parts*, and *Virtues*.

74. When the *Hydroſtatic* BALLANCE is not at Hand, this HYDROMETER will ſupply its Place to an equal Exactneſs for all Liquors into which it can be put, or in which it can freely ſwim, corroſive Fluids only excepted; ſince the Weight that ſinks the Hydrometer to (0) ſhews in this Table the ſpecific Gravity of the Fluid to the 1000th Part of the whole Difference between that and the ſpecific Gravity of Water.

75. This Table is alſo equally uſeful for ſhewing the ſpecific Gravities of all Fluids or ſpirituous Compounds which are leſs than that of Water down to 840; for if thoſe Numbers on the Right-hand of the Dott or Point (in the 2d Column) be added to 840, the Sum will be the ſpecific Gravity of that Fluid which requires the correſponding Weights in the firſt Column to ſink the Hydrometer to (0). For Example, ſuppoſe the Weight be 300, then againſt that is the Number 1,048; if then the ,048 be added to 840, it will make 888 the ſpecific Gravity of that Compound. See Page 10, Part I.

76. On the other Hand, if the ſpecific Gravity of Fluids ſhould exceed 1,160 which is the Extent of this

Table, yet thoſe Numbers will equally ſerve for 160 more, by putting on the *double Water-weight* at Bottom, and adding the Numbers on the Right-hand of the Dott, correſponding to the Weight on the Hydrometer, to the Number 1.160. Thus ſuppoſing the Inſtrument with this double Weight at Bottom, ſhould require the Weight 190 at Top for an Equilibrium with the Fluid; then againſt 190 is the Number 1.0304, and .0304 added to 1.160, makes 1.1904 the ſpecific Gravity of that Fluid, and thus the Uſe of the Table is extended to examine all ſpecific Gravities from 840 to 1.320, which is farther than there can be Occaſion for.*

77. In each Table, the Weights proceed with the Difference of 5, but when great Exactneſs is required, it is eaſy by the Rule of Three to find the proportional Part for any of the other Digits 1, 2, 3, 4, or 6, 7, 8, 9, or by Inſpection with the Sliding-rule. But this can be only neceſſary, when the Compound is within a ſmall Matter of Proof on either Side. And thoſe who are uſed to compute by Tables, know the Proceſs too well to need Examples. So that each Table may be eaſily accommodated to every *thouſandth Part of the whole Difference* in regard to the Quantity or ſpecific Gravity of any Fluid or ſpirituous Compound compared with Water.

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* *N. B.* As this *double Water-weight* can only be of Uſe in very denſe or heavy Fluids, it can be but ſeldom required, and therefore is not made, but when expreſsly ordered.

TABLE I. *Shewing the Number of Gallons of Compound to which one Gallon of* WATER *or* SPITIT *muſt be added to make it* real PROOF.

PART I. ABOVE PROOF.

Weight on the Hydrometer.	Gallons of the Compound to which one of Water muſt be added.	Weight on the Hydrometer.	Gallons of the Compound to which one of Water muſt be added.	Weight on the Hydrometer.	Gallons of the Compound to which one of Water muſt be added.	Weight on the Hydrometer.	Gallons of the Compound to which one of Water muſt be added.
0	0.0000	155	1.6050	305	2.4213	455	4.9261
5	1.2005	160	1.6233	310	2.4630	460	5.1020
10	1.2117	165	1.6420	315	2.5062	465	5.2910
15	1.2210	170	1.6611	320	2.5510	470	5.4945
20	1.2325	175	1.6806	325	2.5974	475	5.7143
25	1.2422	180	1.7007	330	2,6455	480	5.9523
30	1.2531	185	1,7211	335	2.6340	485	6.2111
35	1.2642	190	1.7421	340	2.7472	490	6,4935
40	1.2755	195	1.7536	345	2.8011	495	6.8027
45	1.2840	200	1,7867	350	2.8572	500	7.1428
50	1.2988	205	1.8083	355	2.9154	505	7.5188
55	1.3107	210	1.8315	360	2.9761	510	7.9365
60	1.3228	215	1,8553	365	3.0395	515	8.4033
65	1.3320	220	1.8797	370	3.1056	520	8.9285
70	1.3478	225	1.9047	375	3.1746	525	9.5238
75	1.3605	230	1.9305	380	3.2467	530	10.2041
80	1.3736	235	1.9569	385	3.3222	535	10.9890
85	1.3869	240	1.9841	390	3.4013	540	11.9068
90	1.4005	245	2.0121	395	3.4843	545	12.9872
95	1.4144	250	2.0408	400	3.5714	550	14.2857
100	1.4285	255	2.0704	405	3.6630	555	15,8731
105	1.4430	260	2.1008	410	3.7594	560	17.8572
110	1.4578	265	2.1322	415	3.8610	565	20.4082
115	1.4728	270	2.1645	420	3.9682	570	23.8091
120	1.4881	275	2.1978	425	4.0816	575	28.5715
125	1.5038	280	2.2322	430	4.2017	580	35.7144
130	1.5080	285	2.2667	435	4.3290	585	47.6200
135	1.5361	290	2.3341	440	4.4643	590	71.4288
140	1.5528	295	2.3419	445	4.6083	595	142.8572
145	1.5699	300	2.3809	450	4.7619		
150	1.5873						

PART

PART II. Below PROOF.

Weight on the Hydrometer.	Galls. of Compound to one Gallon of Spirit.	Weight on the Hydrometer.	Galls. of Compound to one Gallon of Spirit.	Weight on the Hydrometer.	Galls. of Compound to one Gallon of Spirit.	Weight on the Hydrometer.	Galls. of Compound to one Gallon of Spirit.
600	PROOF.	705	3.2000	805	1.6390	905	1.1016
605	67.2	710	3.0545	810	1.6000	910	1.0831
610	33.6600	715	2.9217	815	1.5628	915	1.0666
615	22.4000	720	2.8000	820	1.5272	920	1.0500
620	16.8000	725	2.6880	825	1.4933	925	1.0338
625	13.4400	730	2.5846	830	1.4608	930	1.0181
630	11.2000	735	2.4889	835	1.4297	935	1.0030
635	9.6000	740	2.4000	840	1.4000	940	0.9882
640	8.4000	745	2.3172	845	1 3714	945	0 9739
645	7.1306	750	2.2400	850	1.3440	950	0 9600
650	6.7200	755	2.1677	855	1.3176	955	0.9465
655	6.1091	760	2.1000	860	1.2923	960	0.9333
660	5.6000	765	2.0363	865	1.2666	965	0.9206
665	5.1692	770	1.9764	870	1.2161	970	0.9081
670	4.8000	775	1.9200	875	1 2218	975	0.8960
675	4.4800	780	1.8667	880	1.2000	980	0.8842
680	4.2000	785	1.8162	885	1.1789	985	0.8727
685	3.9529	790	1.7684	890	1.1586	990	0.8615
690	3.7333	795	1.7230	895	1.1389	995	0.8506
695	3.5369	800	1.6800	900	1.1120	1000	0.84
700	3.3600						

See an Example of reducing theſe decimal Numbers to *Pints*, and *Quarters*, at the End of the next Table.

TABLE II. *For* Merchantable PROOF.

PART I. *Above* PROOF.

0	0.0000	180	0.8488	355	1.2793	525	2.5221
5	0.6350	185	0.8570	360	1.2981	530	2.5963
10	0.6397	190	0.8654	365	1.3175	535	2.6750
15	0.6443	195	0.8740	370	1.3374	540	2.7585
20	0.6490	200	0.8827	375	1.3580	545	2.8475
25	0.6539	205	0.8916	380	1.3792	550	2.9424
30	0.6588	210	0.9007	385	1.4011	555	3.0439
35	0.6637	215	0.9100	390	1.4237	560	3.1526
40	0.6687	220	0.9195	395	1.4443	565	3.2693
45	0.6739	225	0.9292	400	1.4712	570	3.3951
50	0.6790	230	0.9390	405	1.4961	575	3.5309
55	0.6843	235	0.9492	410	1.5219	580	3.6780
60	0.6896	240	0.9595	415	1.5486	585	3.8379
65	0.6951	245	0.9700	420	1.5763	590	4.0124
70	0.7006	250	0.9808	425	1.6050	595	4.2034
75	0.7062	255	0.9918	430	1.6346	600	4.4136
80	0.7119	260	1.0031	435	1.6655	605	4.6460
85	0.7177	265	1.0146	440	1.6975	610	4.9040
90	0.7236	270	1.0264	445	1.7310	615	5.1925
95	0.7295	275	1.0385	450	1.7654	620	5.5170
100	0.7356	280	1.0508	455	1.8015	625	5.8850
105	0.7418	285	1.0635	460	1.8390	630	6.3051
110	0.7481	290	1.0765	465	1.8781	635	6.7901
115	0.7545	295	1.0898	470	1.9190	640	7.3560
120	0.7610	300	1.1034	475	1.9616	645	8.0244
125	0.7676	305	1.1173	480	2.0062	650	8.8272
130	0.7743	310	1.1319	485	2.0529	655	9.8080
135	0.7812	315	1.1464	490	2.1017	660	11.0340
140	0.7882	320	1.1514	495	2.1530	665	12.6103
145	0.7953	325	1.1769	500	2.2063	670	14.7121
150	0.8025	330	1.1928	505	2.2634	675	17.6545
155	0.8098	335	1.2092	510	2.3230	680	22.0681
160	0.8173	340	1.2260	515	2.3857	685	29.4249
165	0.8250	345	1.2432	520	2.4520	690	44.1363
170	0.8326	350	1.2610			695	88.2726
175	0.8407					700	PROOF.

PART II. *Below* PROOF.

700	PROOF.	780	5.9524	855	3.0722	930	2 0704
705	95.2380	785	5.6022	860	2.9761	935	2.0263
710	47.6190	790	5.2910	865	2.8860	940	1.9841
715	31.7460	795	5.0125	870	2.8011	945	1.9436
720	23.8100	800	4.7619	875	2.7210	950	1.9047
725	19.0475	805	4.5351	880	2.6455	955	1.8675
730	15.8730	810	4.3290	885	2.5640	960	1.8315
735	13.6023	815	4.1408	890	2.5062	965	1.7968
740	11.9048	820	3.9683	895	2 4420	970	1.7636
745	10.5820	825	3.8095	900	2.3810	975	1.7316
750	9.5238	830	3.6630	905	2.3229	980	1.7007
755	8.6580	835	3.5273	910	2.2675	985	1.6708
760	7.9365	840	3.4013	915	2.2148	990	1.6420
765	7.3260	845	3.2841	920	2.1645	995	1.6142
770	6.8027	850	3.1746	925	2.1164	1000	1.604
775	6.3492						

In theſe Tables, if the decimal Part of the Numbers in the 2d Column be multiplied by 8, the firſt Figure to the Left-hand in the Product will be *Pints*; if the Decimal of that be multiplied by 4, it gives the Quarters of a Pint.

EXAMPLE.

Againſt 815 is ——— ——— ——— 4,1408
Multiply by ——— 8
Pints ——— 1,1264
4
Quarters —— 0,5056

Therefore to 4 Gallons, 1 Pint, and ½ a Quartern of this Compound, one Gallon of *Alchohol* muſt be added for *Merchantable Proof.*

TABLE III. *Of* Specific GRAVITIES.

Weight on the Hydrometer.	Specific Gravity of the Fluid.	Weight on the Hydrometer.	Specific Gravity of the Fluid.	Weight on the Hydrometer.	Specific Gravity of the Fluid.	Weight on the Hydrometer.	Specific Gravity of the Fluid.
0	1.0000	155	1.0248	310	1.0496	465	1.0744
5	1.0008	160	1.0256	315	1.0504	470	1.0752
10	1.0016	165	1.0264	320	1.0512	475	1.076
15	1.0024	170	1.0272	325	1.052	480	1.0768
20	1.0032	175	1.028	330	1.0528	485	1.0776
25	1.004	180	1.0288	335	1.0536	490	1.0784
30	1.0048	185	1.0296	340	1.0544	495	1.0792
35	1.0056	190	1.0304	345	1.0552	500	1.080
40	1.0064	195	1.0312	350	1.056	505	1.0808
45	1.0072	200	1.032	355	1.0568	510	1.0816
50	1.008	205	1.0328	360	1.0576	515	1.0824
55	1.0088	210	1.0336	365	1.0584	520	1.0832
60	1.0096	215	1.0344	370	1.0592	525	1.084
65	1.0104	220	1.0352	375	1.060	530	1.0848
70	1.0112	225	1.036	380	1.0608	535	1.0856
75	1.012	230	1.0368	385	1.0616	540	1.0864
80	1.0128	235	1.0376	390	1.0624	545	1.0872
85	1.0136	240	1.0384	395	1.0632	550	1.088
90	1.0144	245	1.0392	400	1.064	555	1.0888
95	1.0152	250	1.040	405	1.0648	560	1.0896
100	1.016	255	1.0408	410	1.0656	565	1.0904
105	1.0168	260	1.0416	415	1.0664	570	1.0912
110	1.0176	265	1.0424	420	1.0672	575	1.092
115	1.0184	270	1.0432	425	1.068	580	1.0928
120	1.0192	275	1.044	430	1.0688	585	1.0936
125	1.020	280	1.0448	435	1.0696	590	1.0944
130	1.0208	285	1.0456	440	1.0704	595	1.0952
135	1.0216	290	1.0464	445	1.0712	600	1.096
140	1.0224	295	1.0472	450	1.072	605	1.0968
145	1.0232	300	1.048	455	1.0728	610	1.0976
150	1.024	305	1.0488	460	1.0736	615	1.0984

Weight on the Hydrometer.	Specific Gravity of the Fluid.	Weight on the Hydrometer.	Specific Gravity of the Fluid.	Weight on the Hydrometer.	Specific Gravity of the Fluid.	Weight on the Hydrometer.	Specific Gravity of the Fluid.
620	1.0992	720	1.1152	815	1.1304	910	1.1456
625	1.100	725	1.116	820	1.1312	915	1.1464
630	1.1008	730	1.1168	825	1.132	920	1.1472
635	1.1016	735	1.1176	830	1.1328	925	1.148
640	1.1024	740	1.1184	835	1.1336	930	1.1488
645	1.1032	745	1.1192	840	1.1344	935	1.1496
650	1.104	750	1.120	845	1.1352	940	1.1504
655	1.1048	755	1.1208	850	1.136	945	1.1512
660	1.1056	760	1.1216	855	1.1368	950	1.152
665	1.1064	765	1.1224	860	1.1376	955	1.1528
670	1.1072	770	1.1232	865	1.1384	960	1.1536
675	1.108	775	1.124	870	1.1392	965	1.1544
680	1.1088	780	1.1248	875	1.140	970	1.1552
685	1.1096	785	1.1256	880	1.1408	975	1.156
690	1.1104	790	1.1264	885	1.1416	980	1.1568
695	1.1112	795	1.1272	890	1.1424	985	1.1576
700	1.112	800	1.128	895	1.1432	990	1.1584
705	1.1128	805	1.1288	900	1.144	995	1.1592
710	1.1136	810	1.1296	905	1.1448	1000	1.160
715	1.1144						

——— *Si quid noviſti rectius iſtis,*
Candidus imperti; ſi non, his utere mecum.

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